Hard X-ray Telescope
Glass Optics Development

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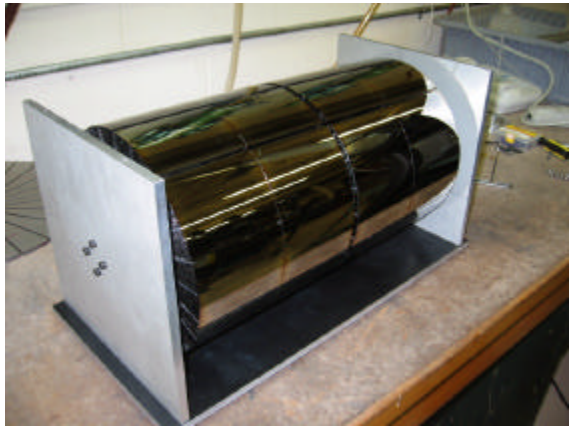
HXT Glass Optics Technology

- Epoxy-replicated, thermally-formed glass substrates, graphite spacer mounting
- HXT mirrors of thermally-formed glass with epoxy replication are similar in concept to SXT, however required resolution is 4x larger, mirror dimensions are significantly smaller:
  - HXT uses conical approximation: mandrels are much less expensive and can be cylindrical or conical.
  - Can utilize simpler, already-proven mounting approach
  - Have recently demonstrated that larger-radius shells do not require replication to meet 60" requirement: cost savings
- HXT development can leverage some aspects of SXT program: in particular the replication and forming processes.



HEFT Module, 72 shells.

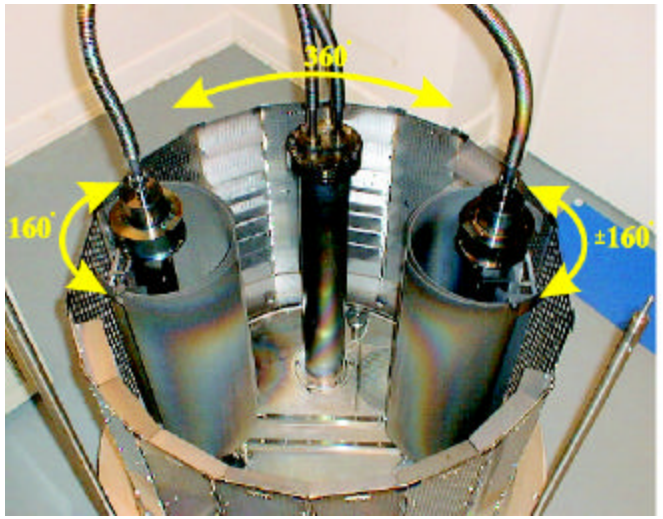
HXT Baseline Glass Mirror Parameters

Parameter	Description
Design	Segmented conical approximation
Substrate material	Thermally formed glass
Reflecting surface fabrication	Epoxy replication
X-ray reflecting surface	W/Si graded multilayer
Number of shells/mirror	150
Reflector length	25 cm
# azimuthal segments	6
Largest reflector surface area	130 cm^2
Outer, inner mirror radius	20cm, 3cm
Substrate density	2.4 g/cm^3
Reflector thickness	0.3 mm
Reflector roughness	0.4 nm

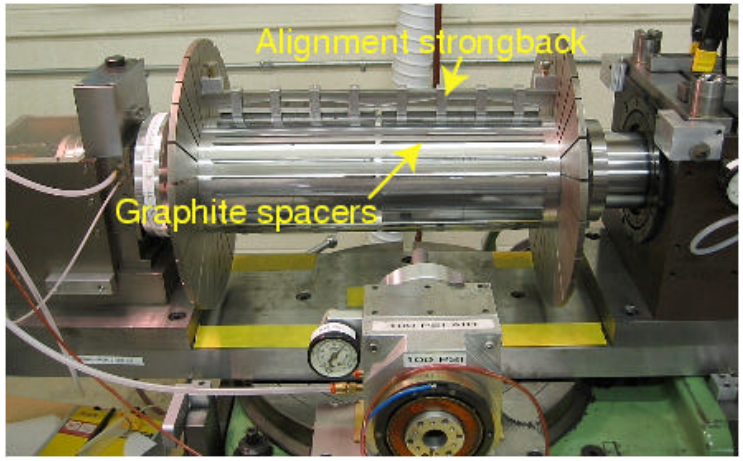
HXT technology Status Summary

All production steps have been demonstrated

Thermal forming and replication (Columbia & GSFC)

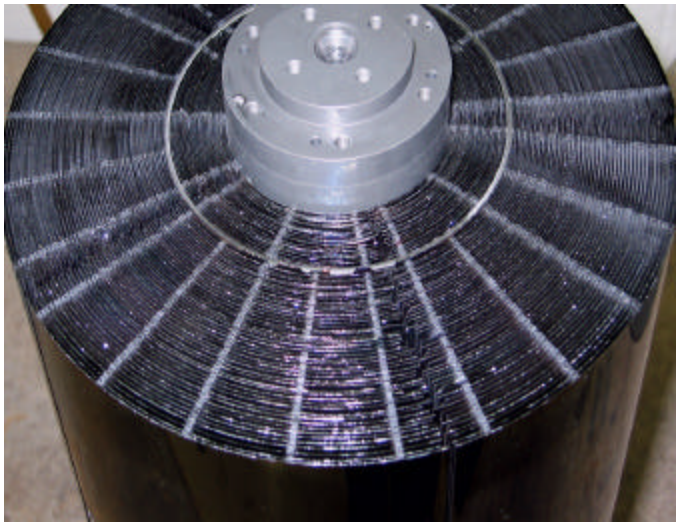


Multilayer coating in high-throughput chamber (DSRI)

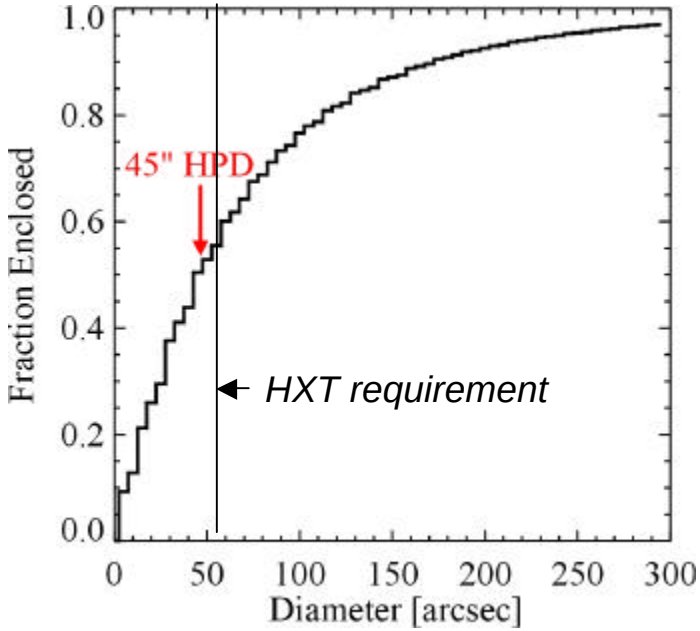


Shell mounting (developed by Columbia/LLNL and transferred to industry)

HXT Technology status: mirrors



HEFT flight mirror

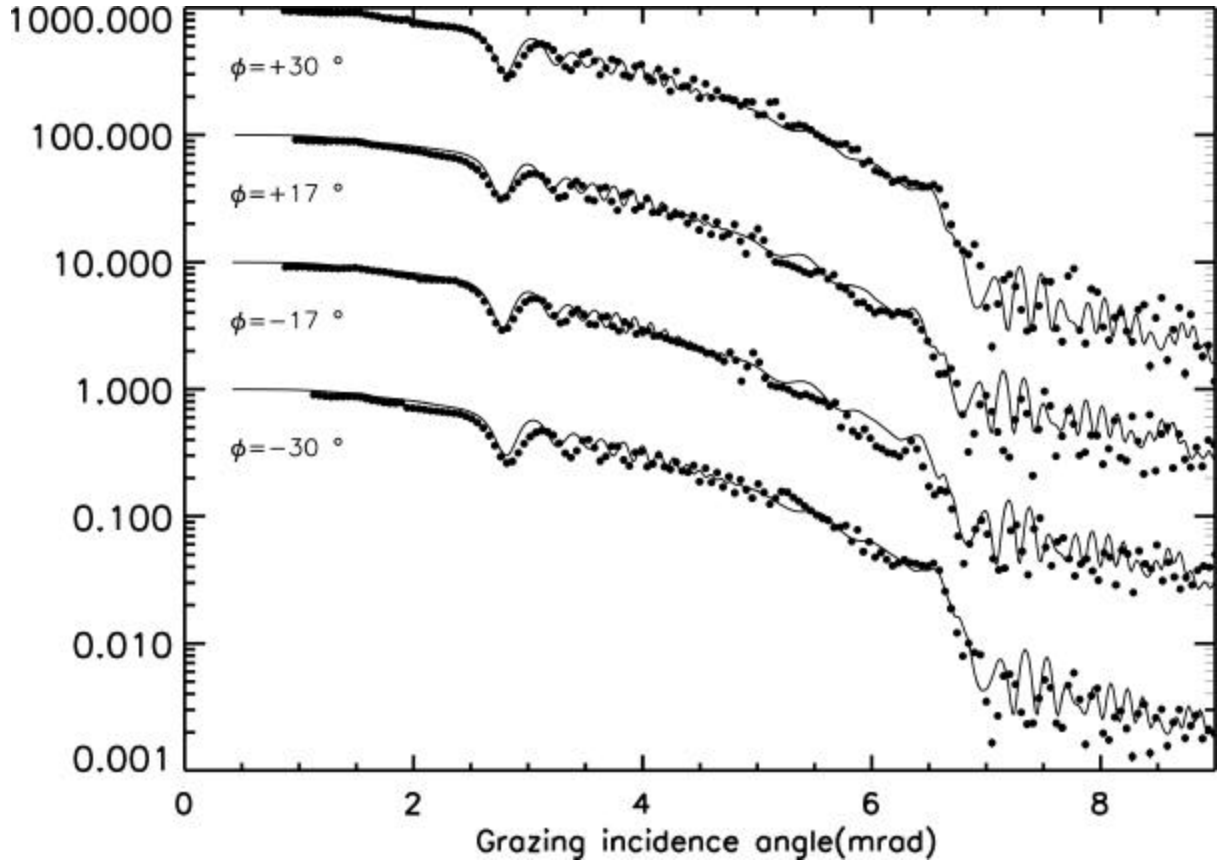


- **Glass segments without replication coated, assembled into 72-shell optic**
- **Demonstrated 45” on a Con-X prototype consisting of unreplicated intermediate-size shells**
- **Uncoated, replicated shells mounted and characterized.**

  Poor mandrel limited performance, uncoated due to high roughness

HXT Technology status: mirrors

Required multilayer reflectance has been demonstrated on formed glass of appropriate radii (but without replicated surface).



34 keV data taken at ESRF - graded W/Si multilayers

Glass mirror development plan

Produce 6-shell prototype with replicated glass, some segments coated with W/Si multilayers of Con-X design.

Characterize prototype with X-ray beam scans for HPD, reflectance, throughput.

Results of this prototype development will be used to select the technology for development of full-size prototype.

HXT optics prototype

Technology selection prototype ***Engineering prototype***

	Glass - replica surface	Nickel	Selected technology
Shell thickness	0.4 mm	0.1 - 0.11 mm	Parameters TBD
Segments/shell	24 (6 azimuthal, 4 axial)	1	TBD
Multilayer	W/Si	W/Si, Iridium	W/Si
Focal length	10 m	10 m	10 m
# shells	6	6	TBD
Shell diameter, length	21 cm, 10 cm 20 cm	15 (1 shell) - 28 cm, 43.6 cm	Span full radius range in design
goals	▪Demonstrate 30” HPD resolution with replica shells ▪Demonstrate coating on replica surfaces ▪Demonstrate required throughput	▪Demonstrate HPD for thin Ni shells ▪Demonstrate internal ML coating technique ▪Demonstrate required throughput	▪Thermal/vacuum test for stability and robustness of components and to experimentally establish flight requirements ▪Demonstrate performance for representative shells covering entire radius range ▪Mechanical/vibration test for stability, and to establish isolation requirements
Timeframe	Selection: 12/03		

Prototype Development Status

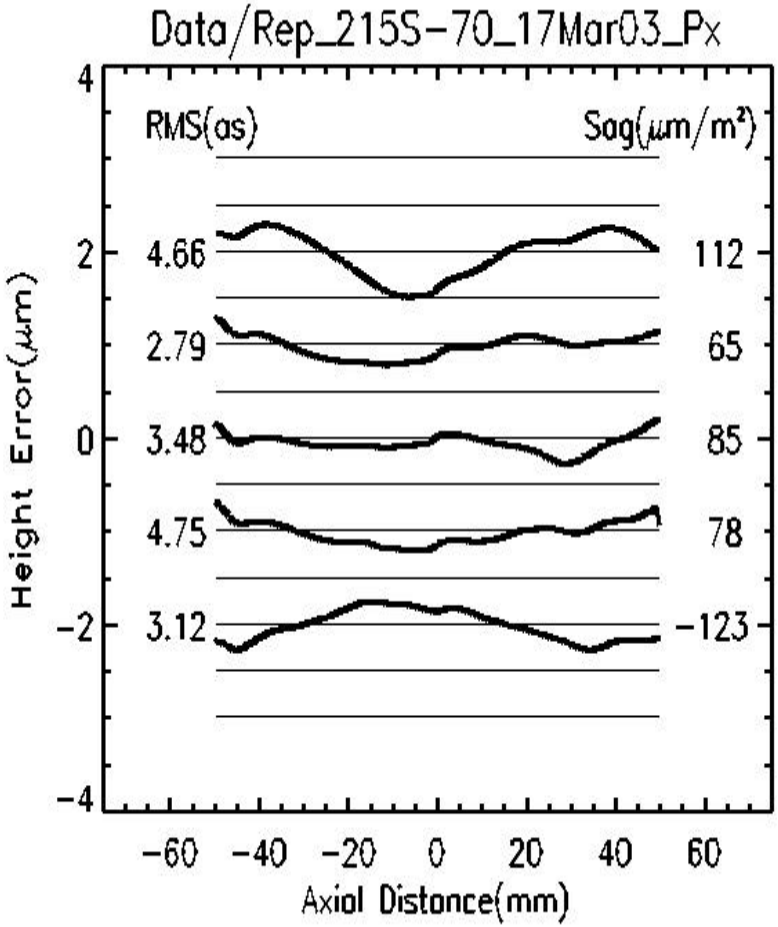
Two replication mandrels procured:

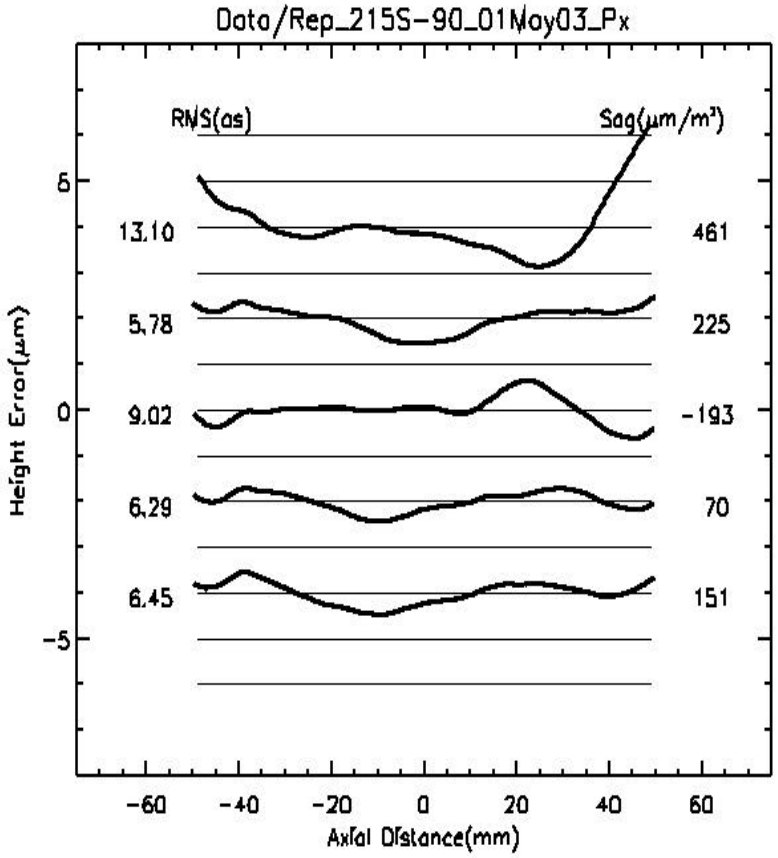
21 cm diameter BF Goodrich mandrel being polished by GSFC to 4.5 Angstroms rms.

10 cm diameter Zerodur mandrel polished to 3 Angstroms purchased from SESO (France)

GSFC/Goodrich mandrel ready for replication, SESO mandrel to be received this month

Prototype Status





Glass Prototype Schedule

Reflector production complete by August, 03

Reflector mounting complete by October 03

Prototype testing October-November 03

Technology selection - December 03